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CAMERON STATION, ALEXANDRIA, VIRGINIA



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2000 NINTH AVENUE SOUTH
BIRMINGHAM 5, ALABAMA

April 11, 1963

AIR MAIL

Commanding Officer
U.S. Army Chemical Research
and Development Laboratories
Edgewood Arsenal, Maryland

Attention: Mr. Abraham Koblin
Contract Project Officer

Reference: Monthly Progress Report
Contract No. DA18-108-AMC-32-A

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Dear Sir:

~~The study to develop~~ ^{DEVELOPMENT OF} instruments for measuring particle size and concentration of chemical agents was continued during March. A breadboard model flash camera was assembled and experimental evaluation was started. Two special electrochemical cells were made to explore the relation between the response time of the cell and the thickness of the oxime layer. An analysis of thermal precipitation was made to determine the basic factors for designing a thermal precipitator for chemical agents. This report gives the results of the experimental work with the camera and the cells, and a summary of the analysis of the therm l precipitator.

The breadboard model flash camera described in the last progress report was assembled and experimental studies have been started. The present system is composed of a flash illuminator and a vidicon television camera. A 16-mm lens with a focal length of 75mm was used for an objective lens and arranged to give a magnification of four at the vidicon. With a 14-inch television monitor the total magnification of the system is about 120 diameters. The monitor is necessary for focusing and qualitative evaluation of the system, but it will not be used for actual particle size measurements with the final camera.

For our first studies we used a Polaroid camera with a copying lens to photograph the TV monitor. Several different powders and aerosols

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have been tried and particles are easily visible on the monitor. The particle size range of these powders was not known. However, we could see particles that were about 5mm diameter on the monitor, and the actual size of these particles was estimated from the known magnification to be about 50 microns diameter. These particles were seen during the first experiments with the camera, and 50 microns diameter should not be considered as the smallest size that the camera is capable of detecting. More experiments are planned with smaller particles after several improvements have been made on the flash camera.

During our first experiments we used the objective lens at full aperture of $f/1.4$. To increase the depth of field, we stopped the lens down one stop at a time until the brightness was too low to get a satisfactory image on the monitor. At $f/2$ and $f/2.8$ the images of the particles were still bright. At $f/4$ some of the particles were still visible, but at $f/5.6$ we could not see the particles. The improvement in focus at $f/2.8$ and $f/4$ was apparent on the monitor screen. When the image intensifier is added to the system in April we should be able to operate at $f/4$ or even at a higher focal number.

The present performance of the electrochemical cell will be adequate for measuring total agent concentration. However, to measure agent concentration as a function of time the response time of the cell must be improved. Several experiments have been conducted to learn more about the factors that affect the response time. The following results indicate that the response time can be improved by reducing the thickness of the oxime layer. More experiments on the cell response time are planned for April.

Two cells were designed and built to measure the response as a function of the thickness of the oxime film. A flat silver plate was used as the anode in each cell, and a sheet of platinum was used for the cathode. The cells differed slightly in the size of the electrodes and in their configuration. Both cells were designed in an open-cup form. Cell A contained a 10mm diameter silver anode; the vertical wall of the cup was the platinum cathode which was separated from the silver by 1.0mm of epoxy resin. Cell B contained a 16mm diameter sheet silver anode surrounded by a sheet-platinum ring in the same plane as the silver, and separated from the silver by a 1.0mm space. The wall of the cup was formed by a rubber ring.

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In cell A the average film thickness over the silver electrode was determined with a microscope. The film thickness, estimated as 0.03mm, could not be accurately measured with a microscope and this value was estimated by a comparison of the other values with the known volumes of solution added to the cell. An air stream containing 2.9 micrograms of HCN per liter was directed onto the surface of the oxime solution at a flow rate of 1 liter per minute. The following data were obtained with cell A:

Average Film Thickness (mm)	Δi , Maximum, (μa)	Time to Reach Maximum Δi , (min)
0.54	no response	--
0.24	0.5	>1
0.16	3.4	0.21
0.09	4.8	0.10
0.03 (estimated)	6.2	0.10

The following data were obtained with cell B with an air stream containing 2.2 micrograms of HCN per liter:

Calculated Film Thickness (mm)	Δi , Maximum, (μa)	Time to Reach Maximum Δi , (min)
0.61	4.95	1.0
0.44	7.85	0.7
0.26	10.38	0.4
0.09	8.14	0.3

The film thicknesses for cell B were calculated from the known volumes of solution added to the cell. The actual film thicknesses above the silver anode would be considerably smaller since a large portion of the solution is concentrated close to the cell wall by capillary action. This was also observed with cell A. The 0.09mm film had evaporated after a 1 minute exposure to the air stream, causing the current change to be less than that observed with the 0.26mm film.

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The results with both cells show that a marked increase in response is obtained as the film thickness is decreased. Except for rapid evaporation a film thickness on the order of 0.1mm, or less, would appear to be desirable.

Thermal precipitation may be a useful method for removing aerosol particles from a gas stream without removing the vapor. The reason for this is that thermal forces are the only ones of the available forces that act as well, or better, on small particles than on large ones. The theoretical derivation indicates that the velocity of a particle in a thermal gradient is substantially independent of the particle diameter except for small particles approaching $4/3$ times the mean free path of the gas molecules. In this case the viscous drag of the gas is small, and the thermal velocity is therefore greater.

The derivation of the thermal forces according to Epstein (Z. Physik 54, p. 537, 1929) and modified by Rosenblatt and LaMer (Phys. Rev 70, p. 385, 1946) gives design information which indicates a very low sampling rate for a reasonable size unit. Commercially available thermal precipitators use a variable sampling rate to be certain of 100% precipitating efficiency. In addition, the optimum sampling rate for the agent detector is still unknown. Therefore, our alternatives are: (1) to buy a commercial thermal precipitator for about \$500 and use it in the hope that it will not prove much too small for the required sampling rate, or (2) to design and build a thermal precipitator to accommodate the large sampling ranges expected.

The approximate size of a thermal precipitator was estimated after making the following assumptions:

1. Thermal conductivity of the aerosol particle = $0.00033 \frac{\text{cal}}{\text{sec cm } ^\circ \text{K}}$.
2. The maximum particle diameter = 200 microns.
3. Temperature difference between the plates = 100°C .
4. Sample rate = 1 liter per min.

For these assumptions the area of the unit would be 1870 cm^2 , or about 50 cm in diameter. These calculations will be refined when the thermal conductivity of the agents is furnished by CRDL. The design details of the thermal precipitator will be discussed in a later report.

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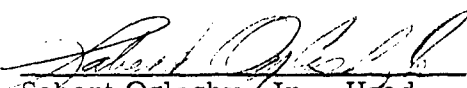
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During April an image intensifier tube will be installed on the camera and the experiments will continue. The response of the image intensifier is much faster than the vidicon and we should get much better sensitivity. From the next experiments we should learn the smallest size particle that the camera will detect, and we should also be able to evaluate our electronic counting circuits. A chemical cell has been designed to swirl the agent aerosol over a moving oxime layer. This will give turbulent mixing and should increase the rate of absorption of the agent. Because the thin oxime layer is moving and being replenished, this cell design will reduce the effect of evaporation. The work with the camera and the cell will be continued during April, and the project staff will remain about the same. This report was prepared by Don Brady, Norman Francis, and Alvin Bird.

Yours very truly,


Alvin N. Bird, Jr.
Research Physicist
Instrument Development Section

Approved:


Sabert Orlesby, Jr., Head
Engineering Division

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